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PRACTICAL NOTES ON URINARY ANALYSIS.

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REPRINT FROM THE MARYLAND MEDICAL JOURNAL.

BALTIMORE:
JOURNAL PUBLISHING COMPANY PRINT,
209 Park Avenue,
1887.

PRACTICAL NOTES ON URINARY ANALYSIS.

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The importance of a knowledge of the study of urinary analysis need not be pointed out here. It is generally admitted that in every case of doubtful diagnosis the urine should be examined. The science, (if it may be socalled) of urinary analysis has been, however, carried to such a refinement that an expert chemist alone is able to master it in all its detail. The busy practitioner has no time to search through manuals and make elaborate tests. In the light of many advances made in this department several old tests have shown themselves trustworthy and many new ones have been added. The object of these notes will be, after reviewing the general character of the urine, to endeavor to show the tried and reliable tests for detecting normal and abnormal substances in the urine, and at the same time to try to

point out the little errors that may creep in in such an undertaking, and to guard against certain mistakes by clearly stating the important and carefully avoiding the superfluous. Besides drawing largely from his own experience, the writer has unhesitatingly made use of the literature of the subject.

GENERAL CHARACTER OF THE URINE.—1. *Quantity.*

The amount of urine passed in health during twenty-four hours by a man is about forty to fifty fluid ounces, and by a woman slightly less. This amount may be temporarily *increased* in health

a. By drinking larger quantities of liquid.

b. By diminished skin activity, as in cold or damp weather.

c. By taking diuretics.

This amount may be *diminished*

a. By drinking little liquid.

b. By rest.

c. By profuse perspiration.

The most urine is passed in the afternoon and the least at night. Pathlogically the amount is *increased*

a. In diabetes mellitus and insipidus.

b. In granular atrophy of the kidney.

c. In pyelitis.

d. By the absorption of dropsical fluids from the body.

Pathologically the amount is *diminished.*

a. In fever.

b. In the acute and chronic forms of parenchymatous nephritis.

c. In cholera.

d. In the formation of dropsical fluids.

e. In those heart troubles where the blood pressure is diminished.

2. *Color.*

Normal urine may vary in color from a pale yellow to a brownish black according to its concentration. The color of the urine is a very important factor in the diagnosis at the bedside. A light clear urine (*urina spastica*) would show absence of acute fever and a possible presence of polyuria; while a dark colored urine would denote not only a fever, but might signify a variety of affections of the spleen or liver, a hearty meal, active exercise, etc. Reddish or reddish-brown urine would point to blood, black urine to the presence of the pigment of melanotic cancer (melanuria). Green or brownish-green urine would indicate bile.

Different drugs have a decided effect on the color of the urine; for example, rhubarb (chrysophanic acid), senna and santonin make it intensely yellow or a

greenish or brownish yellow. Further logwood, strong coffee, turpentine, carbolic acid, tar, creasote fol. uvæ ursi, kairin and fuchsin all color the urine. It is not probable that the presence of albumen can be suspected by the color.

3. *Smell.*

The smell of urine may best be described by saying that it is urinous. When concentrated it is strong, when ammoniacally decomposed it is still stronger and even putrescent. It is affected by certain drugs. Turpentine gives it the odor of violets. The odor of cubebs, copaiba, sandalwood, costoreum, valerian is imparted to urine after administration by the mouth. Also after eating certain vegetables, such as garlic, asparagus, cauliflower, etc., the urine has a peculiar smell. In diabetes mellitus it may have a sweet smell.

4. *Transparency and Consistency.*

Normal urine is always clear when first passed and shows on standing a slight cloudiness (nubecula) more noticeable in the urine of women. Microscopically a few epithelial and other cells are always present and in the case of females, vaginal epithelium. Patho-

logically the presence of the earthy phosphates of lime and magnesium, of the urates, pus, mucus, blood, etc., causes cloudy urine. Normally urine is aqueous. Pathologically the presence of mucus or pus may cause it to be viscid and also chyle in the urine (chyluria), as observed in the tropics gives it a turbid and thick appearance. The foam which normally so quickly disappears from urine may remain in the presence of sugar, albumen, or blood.

5. *Reaction.*

The reaction of normal urine is generally acid. The cause of this is not certain although it is very likely due to the presence of the acid phosphate of sodium (N_a, H_2, PO_4,) and other salt. The reaction is tested by means of litmus paper. Acid urine turns blue litimus paper red and alkaline urine turns red litmus paper blue. Normally the urine may be alkaline immediately after meals. The acidity is greater

a. In concentrated urine after perspiration.

b. After fasting.

c. After eating much animal food.

d. After exercise.

e. In fever.

The urine is only faintly acid or even alkaline

a. Just after meals.

b. When very dilute.

c. After taking certain mineral waters and other alkalines.

d. After repeated vomiting.

Pathologically the urine is alkaline in cystitis and by decomposition after it has left the bladder.

The alkalinity may be due to a fixed (potassium or sodium) or a volatile (ammonia) alkali. In the former case the litmus paper made blue by the alkali remains blue on drying; in the latter case the blue fades away.

6. *Specific Gravity.*

In taking the specific gravity of urine the proportion between its watery and solid constituents is measured. The specific gravity is measured by means of a urinometer, which consists of a glass tube loaded at its lower end with mercury and with a bulb blown in the middle. Tke stem, the external diameter of which is as regular as possible, is hollow and the scale is marked upon it. A urinometer when immersed in pure distilled water at a temperature of 60° F. should register at 1000. The specific gravity of urine thus measured is normal-

ly between 1015 and 1021 for 40 to 50 ounces per day, and pathologically may vary from 1002 to 1040 and even more. Normally the specific gravity is in inverse proportion to the amount passed in twenty four hours.

In order to take the specific gravity of a given specimen of urine, a large test tube or cylinder should be about ¾ filled with urine and after the bubbles have disappeared or have been removed by bibulous paper, and the urine cooled off to the surrounding temperature, the dry urinometer should be gently dipped into the urine and allowed to float without touching the sides of the vessel, and after all motion has ceased the figures may be read off from the stem of the urinometer. In taking the specific gravity the total amount passed in 24 hours should be known. Normally when the amount of urine is temporarily increased in health the specific gravity is less and *vice versa*. Pathologically the specific gravity is high and the amount of urine passed low

a. In acute febrile diseases.

b. In some form of heart trouble.

In diabetes mellitus the specific gravity is generally high and the amount passed abundant and clear. Exceptionally cases of diabetes mellitus have been reported with abundant urine and low

specific gravity. Generally a low specific gravity with abundant secretion of urine is observed in many constitutional afebrile diseases, such as

a. Chlorosis.
b. Hysteria.
c. Contracted kidney.
d. Diabetes insipidus.

II. Normal Conetituents of the Urine.

A. organic.—1. *Urea.*

Urea forms the most important product of decomposition of the albuminous bodies, and the amount excreted is dependent upon the amount of albumen in the food. As about one-half of the solid constituents of the urine consist of urea; we may most readily determine approximate variations in the amount of the latter by means of the specific gravity. There are many test quantitative and qualitative for the detection of the presence of urea in human urine, but the most convenient is the microscopic test. A drop of urine is put on a glass slide and a drop of nitric acid added and the whole is gently heated over the lamp and allowed to cool. The hexagonal and quadrilateral plates of the nitrate of urea, both single and

in strata, will be formed. They overlap each other like shingles on a roof. In doubtful diagnosis between a hydronephrosis and an ovarian cyst, the presence of the crystals of the nitrate of urea on the former case and their absence in the fluid of an ovarian cyst would be almost decisive. If the urine be free from sugar and albumen, and contain the normal amount of the chlorides, and its specific gravity be 1020–1024, then it should contain normally 2 to 2.5 per cent. of urea. If the specific gravity be 1014 then 1 per cent. of urea. If the specific gravity be 1030 then 3 per cent. of urea.

The amount of urea is *increased*,

a. In an exclusively animal diet.

b. In an increased breaking up of the bodily albumen. As in diabetes mellitus, in fevers before the crisis, in phosphorus s poisoning, in dyspnœa.

The amount of urea is *diminished*,

a. In a non-nitrogenous diet and in inanition.

b. In uræmia.

d. In acute yellow atrophy of the liver.

d. In chronic diseases.

2. *Uric Acid.*

Uric acid is in the urine almost al-

ways combined with potassium, ammonia, calcium, magnesium, sodium, in the form of the urates.

There being bibasic salts we have the neutral and the acid salts. The neutral urates are soluble in water and rarely met with when the acid urates are precipitated and crystallized. Uric acid and the urates appear in the form of rhombic plates, whetstones, barrel, envelop, spear, fan, comb, dumb-bell etc. They are generally colored reddish. Sodium and potassium urate or brick dust sediment is easily soluble in warm water and with difficulty soluble in the cold. It disappears on heating; it adheres to the pot or glass and is more often seen in cold weather, in concentrated urine and when the urine is strongly acid.

Uric acid and the urates are *increased*,

a. In rich animal food with little exercise.

b. In fevers.

c. In leucæmia with enlarged spleen and in pernicious anæmia.

d. In the so-called uric acid diathesis.

e. In all diseases of the heart and lungs and in fact in all conditions (abdominal tumors, liver trouble, etc.) where the function of the diaphragm is interfered with.

Uric acid and the urates are *diminished*,

a. In chronic diseases.

b. During an attack of gout.

The microscopical tests are the most convenient, but require skill. When the red granulated crystals on the bottom and side of the vessel disappear on heating and appear in the cold and disappear on adding caustic potash or soda solution we may presume they are the urates.

3. *Oxalic Acid.*

The presence of the oxalate of lime crystals as envelop-shaped crystals is scarcely of practical importance. They are present in large numbers in so-called oxaluria, and in some calculi. As a slight diminution in the acid phosphate of sodium in the urine causes a precipitate of oxalate of lime crystals their presence can be of little diagnosis importance.

4. *Indican.*

A positive or negative result in testing for this substance is of equal value in a urinary examination. It was found that a certain substance indol was absorbed during digestion and converted in the blood into indican, but during normal intestinal digestion very

little indol was produced while in faulty digestion and allied troubles more was produced and appeared in the urine. Thus indican is *increased.*

a. In all obstructive diseases of the bowel.

b. In pyelitis.

c. In diseases of the spinal cord and nervous system.

d. In urina spastica.

e. After eating.

f. After cholera.

g. In cancer of the liver.

h. In malignant tumors.

i. In Addison's disease.

j. In cancer of the stomach.

k. In acute peritonitis.

The most convenient test is by Jaffé. Equal quantities of clear urine and concentrated pure hydrochloric acid are mixed in a test tube and then a concentrated solution of the chloride of lime is added drop by drop until a blue color is observed. If desired afterward about a drachm of chloroform may be added and the whole shaken by which the chloroform takes up the color and shows its intensity.

B. INORGANIC CONSTITUENTS OF THE URINE.—1. *Chlorides.*

The chlorides are present in the

healthy urine principally as the chloride of sodium with traces of the chlorides of potassium, ammonia and calcium. The amount varies normally according to the amount of common salt taken with the food. The most convenient test for detecting the presence of the chlorides, is the chemical test with the nitrate of silver. If to a given specimen of urine a few drops of nitric acid are first added to keep the phosphates in solution and then a solution of the nitrate of silver be added a white, and in healthy urine, thick flocculent cloud of the insoluble chloride of silver will be precipitated thus proving the presence of the chloride of sodium in the urine thus: $N_a [Cl + Ag] NO_3 = N_a NO_3 + Ag Cl$.

The absence of the chlorides in urine is regarded as a very grave symptom and in watching a case of the acute febrile diseases, particularly of pneumonia it is important to test the urine daily or more often with a nitrate of silver solution, and as the crisis approaches the chlorides will be seen to diminish and may even disappear for a few hours; and after the crisis they begin to reappear. By taking the same amount of urine daily and a silver nitrate solution of known strength the disease can be watched carefully from day to day.

The chlorides are *increased*,

a. When much salt is ingested.

b. After active bodily or mental exercise.

c. During a malarial chill.

d. In diabetes insipidus.

e. When dropsies are removed by diuresis.

The chlorides are *diminished*,

a. In rest.

b. In all acute febrile diseases (exactly the reverse of urea) e. g. in pneumonia when they may be entirely absent at the crisis, a grave omen.

c. In some chronic diseases.

d. In renal diseases with albuminuria and anasarca.

2. *Phosphates.*

The phosphates consist of the alkaline and the earthy phosphates. The former consist of combinations of phosphoric acid with the bases sodium, potassium, etc., are insoluble in water and are not precipitated by alkalies, and need not be further considered. The latter earthy phosphates consist of combinations of phosphoric acid with calcium magnesium, etc., and are shown to be present in urine by adding any alkali which causes a white precipitate, which precipitate, however, is colored by blood,

bile, vegetable coloring matter or any other such pathological constituent of the urine. The phosphates are increased in the urine in all diseases of the bones such as rachitis, osteo-malacia. There is, however, not necessarily an excess of phosphates in the urine simply because they precipitated as the alkalinity of the urine or an application of heat as in testing for albumen may cause them to appear.

III. Abnormal Constituents of the Urine.—1. *Albumen.*

Albumen is the most important abnormal constituent of the urine. Without going into the theory of urinary secretion and excretion it may be sufficient to state that the most generally accepted view of albuminuria is that of Heidenhain which is founded upon the supposition that whenever the continuous epithelial layer on the outside of the convoluted vessels in the glomeruli is in a pathological condition the albumen escapes in the urine. In general, albumen is present in form of serum-albumin, but practically it makes no difference in what form it appears.

Physiologically albumen may be found in the urine of,

a. Infants before the urinary secretion has fairly begun.

b. Weak and delicate children at the age of puberty.

c. Adults after excretion, etc.*

Pathologically it may occur from numberless causes, but its presence is always to be considered as of grave importance. Aside from the so-called accidental albuminuria, in which the albumen does not come from the kidneys, but from the ureters, bladder or urethra we have renal or true albuminuria,

a. In the febrile and infectious diseases.

b. In diseases of the heart and lungs.

c. In actual disease of the kidney.

The tests for the detection of albumen in the urine are various and often complicated. The following are the simplest and most easy of excution and reliable. In all test the urine should be clear and if not clear filtered.

Heat and Nitric Acid Test.

A test tube is filled two-thirds full with the urine and then a few drops of diluted acetic acid added to hold the phosphates in solution. The tube should be held obliquely over the flame and the upper layer heated to the boiling point. If a cloudiness appear which ten to

*See author's article on "Cyclic Albuminuria" in the *Philadelphia Med. News*, July 30, 1887.

twenty drops of strong nitric acid do not dissolve but increase, then albumen is present. In case a slight amount of albumen only be present the precipitate does not appear for a few minutes. This test may be carried out by first heating the urine and if the precipitate which occurs be redissolved by strong nitric acid no albumen is present, but if the urine remains cloudy after the addition of the acid then albumen is present. As an excess of strong nitric acid redissolves a small amount of albumen the acid should be added drop by drop and not more than twenty drops to the amount of urine stated. The test tube should be held against the coat sleeve or a dark back ground and allowed to stand for five minute before a decision is made.

Heller's Test.

This is by far the most reliable and convenient test offered. About two inches of clear urine are poured into a test tube, which is held obliquely while strong nitric acid is poured down the side of the glass and allowed to flow below the urine without being mixed with it. At the junction of the two fluids the slightest trace of albumen will cause a cloudy ring of albumen. In-

stead of a test tube a conical glass may be used. Of course the result will be the same if the urine be carefully poured upon the acid, or if the latter be passed under the urine by means of a pipette. A well defined ring-shaped cloudiness may also be caused by urea and uric acid (in which case it is higher up) or by certain resinous substances as in cubebs, copaiba, turpentine, etc., (in which case the cloudiness is at once redissolved by alcohol.)

Picric Acid Test

A few drops of a saturated watery solution of picric acid are added to clear urine and if albumen be present a slight cloudiness will show itself at once. Any cloudiness which may appear later need not necessarily be due to albumen.

Great care is necessary in carrying out all these tests and in many cases it is only after testing urine from a patient at several different times that a decision can be reached. In carrying out the first test the phosphates should not be taken for albumen merely because they are precipitated by heat. Again the presence of a small amount of albumen may be redissolved if too much nitric acid be added. In using the heat test

on albuminous urine which contains a cloudy precipitate of the acid urates a very striking contrast may be observed by slightly warming the middle part of the urine until the urates here are redissolved and heating the upper layer to a boiling point until not only the urates have been redissolved, but the albumen has been precipitated and then the urine in the test tube will be clear in the middle while the lower layer will contain a precipitate of the acid urates and the upper part a precipitate of albumen. It is advisable to test urine as soon as possible after the specimen has been passed, for at all seasons, but especially in warm weather, the urine becomes decomposed and alkaline and large amounts of the carbonates (of ammonia) and uncombined carbonic acid gas are present. This also the case when the patient has been drinking certain alkaline mineral waters. When such urine is examined for albumen and nitric acid is added a lively effervescence takes place and carbonic acid gas is set free. It is often difficult to decide whether such urine contains albumen or not, for if the albumen be present in a small quantity it is liable to be redissolved by the large amount of acid necessarily added until all effervescence ceases. It is sometimes

desirable to compare the amount of albumen in the urine of the same patient from day to day. The process of precipitating the albumen filtering and weighing the filtrate (the weight of the filter paper being known) is too time-wasting for a busy man. Approximately the amount per cent. may be estimated by taking test tubes of equal size, filling them daily to the same point (two-thirds full) and adding the same amount of nitric acid (about twenty drops) and letting the tube stand a few minutes. In general we may say that when the amount of albumen is 2 per cent. to 3 per cent., the whole fluid is completely coagulated. When there is 1 per cent. of albumen present, the coagulum in the test tube reaches halfway up to the level of the urine.

When 0.5 per cent. $\frac{1}{3}$ the way up.
" 0.25 " $\frac{1}{4}$ " "
" 0.1 " $\frac{1}{10}$ " "
" 0.05 " the curved part of the tube is barely filled with albumen, and whe n there is less than 0.01 per cent. present, there is a slight cloudiness, but no precipitate.

III. Abnormal Constituents of the Urine.

2. *Sugar.*

Although various kinds of sugars are pathologically present in the urine such as sugar of milk (lactose) in the urine of lying-in women, also occasionally inosite and levulose, still these are of minor importance and when we speak of sugar in the urine we generally refer to *glycosuria*, meaning the presence of grape sugar (glucose, dextrose) in the urine. Von Brücke and Bence Jones proved several years ago that a trace of grape sugar was present in all normal human urine, but in such small amount that it escapes the ordinary tests and hence this needs only a mention here. Just as the mistake is so often made of saying that a man with albumen in the urine has Bright's disease, so a man with sugar in the urine is often said to have diabetes mellitus and hence with the disappearance (practically speaking) of these two abnormal ingredients of the urine, hopeless cases of Bright's disease or diabetes mellitus have been said to be cured.

Pathologically sugar may appear in the urine as a (a) transitory or a (b) permanent condition.

As a transitory condition it is described as

a. Glycosuria.

As a more lasting or permanent condition when associated with other symptom it is called,

b. Diabetes mellitus.

a. Glycosuria may occur after taking certain poisons or drugs and in consequence of disturbances of the digestion or nervous system.

b. If the glycosuria continue it may bring certain other symptoms with it and then we have a *diabetes mellitus.*

The tests for detecting the presence of sugar are so numerous that is no easy matter to be master of them all. In carrying out these tests, however, it must be remembered that if albumen be present it should first be precipitated and removed by filtration before the sugar test is made.

Before testing for sugar the specific gravity of the urine should be taken. If it is 1030 the presence of sugar should be suspected, if 1035 and over, the suspicion of sugar should be very strong. Further, if the urine be very pale and and exceed 50 ounces per day, with high specific gravity sugar is almost sure to be present. It should not be forgotten, however, that many cases of glycocosuria with large quantity of urine

and with low specific gravity have been reported.

Moore's or Heller's Test.

This is a favorite test in Germany. A small quantity of urine is heated with one-third its volume of a concentrated caustic potash solution in a test tube and if sugar be present the urine turns a yellow, yellow-brown or brown color according to the amount of sugar present. This test is not reliable when the sugar contained is 0.5 per cent. or less. The urine must be boiled for several minutes. The presence of rhubarb or senna in the urine may cause a similar reaction. Although not a delicate test, still it is a reliable one if it yield a negative result, and hence it is good as a preliminary test.

Copper Tests.

These all depend upon the power which grape sugar possesses of reducing the oxide of copper and are therefore called reduction tests.

Trommer's Test.

As in the first test, to a quantity of urine one-third its volume of a caustic

potash or soda solution is added, then a sulphate of copper solution (1:10) is added drop by drop until there is only a small part left undissolved on shaking the tube. If this mixture be then heated, the presence of sugar will cause, before the boiling point is reached a yellow-red precipitate of cuprous oxide (Cu_2O). If no sugar be present the fluid will show a greenish hue. If a precipitate does not form at once on heating the tube, the test has no value. Occasionally certain drugs in the urine are capable of reducing the copper, and it is possible that these are in the urine. Many reducing agents which the chemists do not yet understand make this test of doubtful value. If the sulphate of copper solution be boiled first and then added the test is strengthened, or if the sulphate of copper solution be added in the cold, and the test-tube be set aside for twenty-four hours the test is more reliable, since sugar is probably the only substance which reduces copper in the cold.

The other copper tests of Fehling and Pavy are both reduction tests and not as convenient as the last. Pavy's pellets are also convenient for bedside tests but they are apt to change and become unreliable.

Böttger's Bismuth Test.

This is a simple and reliable, but not delicate test. The urine is made alkaline by adding equal parts of liq. potassæ or sodæ and then a pinch of subnitrate of bismuth, and boiling for a few minutes. If sugar be present it reduces the bismuth and the black metal will be deposited on the sides of the test tube.

The value of the *Picric Acid Test* is doubtful.

The *Fermentation Test* and *Polarization Test* may be omitted.

The *Phenylhydrazin Test* is the latest and probably most sensitive and reliable test for glucose. It was introduced by Emil Fischer in 1883 and since that time has been carefully studied and modified by v. Jaksch, of Vienna. Two pinches of the muriate of phenylhydrazin and four pinches of the acetate of sodium are put into a test tube with water and heated, then an equal quantity of urine is added and the whole is again heated and set aside to cool. If sugar is abundant it falls down in delicate crystals. If only a small amount is present the delicate yellow crystals of phenylglucoazone may be recognized under the microscope. This test is a very satifactory one, but

takes more time in case a small amount of sugar is present.

3. *Blood.*

Blood occurs in the urine in two different forms.

a. As *Hæmaturia*, when the blood coloring matter is present in the urine in combination with blood corpuscles, and

b. As *Hæminoglobinuria*, when very few or no blood corpuscles are present and the blood is in solution in the urine.

In *Hæmaturia* the blood may come from the kidneys, pelvis of the kidney, ureters, bladder, urethra or vagina. The presence of blood may be suspected by the brownish-red color of the urine and the reddish sediment which appears on standing.

The most convenient and reliable test is to examine this sediment microscopically. It may not be out of place here to give a warning against unclean vessels and bottles in which urine is saved and brought for examination. It seems almost needless to state that cleanliness is very important in saving urine for examination. It has happened that spermatozoa have been found in female urine and vaginal epithelium in male urine. But more often from the female do we

get foreign substances in the urine and therefore it is well to request women to use a Davison syringe before the water is passed or to pass the first part in one chamber and the rest in a clean chamber for examination. With a power of 300 diameters the blood corpuscles can be easily recognized either in their usual bi-concave form or, if the urine be concentrated and acid they appear with crenated edges and much shrunken.

Heller's Test.

This convenient and easy test is made by adding a caustic soda solution to some urine in a test-tube and heating. The precipitated phosphates are colored reddish-brown by the blood-coloring matter and fall in a thick cloud to the bottom of the tube. Testing for *hæmin* crystals is difficult for the inexperienced and may be omitted. If hæmorrhage occur in the urinary tubules, casts or cylinders made up of blood corpuscles are seen under the microscope.

a. Hæmoglobinuria occurs in some fevers, nervous troubles from burns and after carbolic acid poisoning. So-called paroxysmal or periodic hæmoglobinuria has been lately described as a disease due to sudden effect of cold on the skin and particularly the feet. It is

often connected with syphilis. Albumen is often present from the dissolution of the blood corpuscles. If Heller's test gives a positive result and no blood corpuscles are visible under the microscope then we may conclude it is hæmoglobinuria.

4. *Pus.*

Purulent urine is cloudy, grayish-yellow with a heavy sediment which, in alkaline urine has the appearance of a tough stringy mucus like mass. Thus the chemical test for pus is to add a solution of caustic potash to the urine and observe whether the sediment takes on the above described appearance. Much more reliable is the microscopical test which shows at once the presence or absence of the pus corpuscles. On the addition of a drop of acetic acid the nuclei become distinct and the outline of the corpuscle has a glassy appearance Urine containing pus in large amount generally contains albumen. It is not easy to find the source of the pus. Pus in the urine may resemble mucus. The latter, however, forms a light flocculent cloud which remains suspended in the urine for some time. Microscopically the threads of mucus and the cells are at once recognized, but as the mucus

and pus cells are microscopically identical we must also look for albumen which in pyuria is generally present and in mucinuria may be absent. Mucus is more often seen in the urine of females.

5. *Bile.*

A yellow urine which retains its foam a long time after shaking points to the presence of bile. The clothes are often stained a decided yellow by such urine.

Gmelin's Test.

A few drachms of fuming nitric acid are poured down the side of a test-tube so that it passes below the urine, just as in Heller's test for albumen. At the point of contact of the two fluids, if bile be present, a green ring is observed and below it in order a blue, violet, and finally a yellow ring. The green ring is alone decisive. The presence of albumen does not disturb the test. The same play of colors is observed by putting a drop of the suspected urine on a clean porcelain back ground and putting a few drops of fuming nitric acid by it.

IV. Sediment.

Normal urine is generally clear when just passed. Pathological urine may be passed cloudy or may become cloudy on standing.

A microscopical examination of this cloud or sediment forms the most important part of urinary analysis. For this a knowledge of the use of the microscope is absolutely indispensable, and in this paper all such terms as, objective, eye-piece, tube, stage, slide, cover-glass, pipette, etc., will be used without further explanation.

If the sediment be abundant a drop of it may at once be drawn up with a pipette, dropped on a slide and examined microscopically. If the sediment be scanty the urine should be poured into a conical glass to allow the sediment to fall to the bottom and be collected. All urine contains more or less sediment, which sinks rapidly to the bottom or floats for a long time, or even remains adherent to the sides of the vessel, according to its specific gravity. As an improvement on the conical glass it has been suggested to allow such urine with scanty sediment to stand for twenty-four hours in a vessel with straight sides, such as a cylinder or test-tube with a foot. When the sediment has collected at the flat bottom a pipette is introduced with

the finger on the top and the lower stratum of urine and sediment drawn up and this pipette is allowed to stand in the cylinder, the whole being covered with paper or raw cotton, until this scanty sediment collects at the lower end of the pipette when it is drawn out and dropped on a slide, carefully covered with a cover glass, and examined. The urine may contain such a variety of sediment that careful study is very necessary in recognizing the various substances found. According as the urine is acid, or alkaline, concentrated or dilute the sediment varies, hence a reference to the following table will assist in the examination. Some of these substances are passed out with the urine from the bladder, while others are formed after the urine has been passed.

Organized Matter.

1. Mucus and pus cells.
2. Blood corpuscles.
3. Epithelium.
4. Casts.
5. Spermatozoa.
6. Bacteria.

Unorganized Matter.

Acid Urine.	Alkaline Urine.

Amorphorous.

1. Urate of sodium and potash	1. Phosphate of calcium.
2. Fat	2. Carbonate of calcium.

Crystalline.

1. Uric acid.	1. Urate of ammonium.
2. Oxalate of lime.	2. Triple phosphates,
3. Cystin.	3. Phosphate of calcium.
4. Leucin and Tyrin.	4. Phosphate of Magnesium.

1. *Mucus and Pus Cells;*

Are found in all urine and it is only when they are present in an especially large amount that they are considered pathological. In alkaline urine they swell up and take on a glassy appearance. When they contain fat drops they are probably from some abscess in the rectum, prostate, etc. In women they come from a vaginal secretion. Acetic acid renders the nucleus more distinct.

2. *Blood Corpuscles.*

These have already been discussed above.

3. *Epithelium.*

The epithelium in the urine may come from the bladder, ureter, pelvis of the kidney, kidney, vagina or urethra. Epidermis cells often appear in the field of the microscope when the fingers have come in contact with the slide or preparation. It is probably impossible to distinguish cells of the ureters and renal pelvis and even those of the bladder. The large flat vaginal epithelium may be recognized from its resemblance to the buccal epithelium. The bladder epithelium is easily recognized when the superficial and deep pear-shaped cells are floating together. Much more important is the recognition of the renal epithelium. These cells are polygonal—generally hexagonal—are smaller than the other cells and contain a large nucleus. Their presence in the urine points to grave pathological changes in the kidney. They may appear singly, or adherent to casts.

4. *Casts.*

Tube-casts or epithelial cylinders form by far the most important pathological constituent of urinary sediment. They are so-called because they are supposed to be moulds of the uriniferous tubules

of the kidney. After being thus moulded they shrink and are carried out with the urine. They are supposed to be formed by a coagulable substance in the blood or by some morbid change of the renal epithelium. According to their appearance and composition they have received different names. Their presence points almost certainly to a diseased condition of the kidney. Until recently they were supposed to be accompanied by albuminuria, but as is now known, either albumen or casts may be present without the other. The way to find them in the urine has already been mentioned. If the bottle of urine be placed upside down for twelve hours or longer, enough sediment will be deposited on the cork to be examined. Repeated examinations of the urine are necessary before a decision is reached. Urine containing casts should be examined early after securing the specimen as the bacteria and alkaline fermentation soon destroy the casts. A drop of carbolic acid is said to preserve the integrity of the casts and also other acids have been suggested, but the risk of precipitating the albumen should always be avoided. According to their apperance and composition, casts have received different names. If the mould of coagulated fibrin pass out with the urine with-

out blood or cell, it is called a *hyaline cast* or *waxy cast*. According as epithelium, blood, fat drops, or granular matter (the two last from degenerated epithelium) are adherent to the moulds of fibrin, the casts are called respectively, *epithelial*, *blood*, *fat*, or *granular casts*. These casts vary in diameter (from $\frac{1}{2500}$ to $\frac{1}{500}$ in) according to the part of the tubule from which they come. Hyaline casts are naturally smaller than those to which epithelium, blood, etc., are attached. *Mucus casts* have also been described. Amorphous sediment and crystals may adhere to casts, and they also sometimes arrange themselves in a cylindrical form and deceive the inexperienced. Casts of the urates and of bacteria may be mentioned. In cleaning slides and cover-glasses bits of linen threads are left on the glass and may be mistaken for the hyaline cast.

5. *Spermatozoa*;

Are present in the urine occasionally and are of interest from a medico-legal standpoint when found in the urine of women.

6. *Bacteria*;

Are observed in the alkaline fermentation.

The *unorganized sediment* consists of amorphous and crystallized matter which has no very decided clinical significance (with a few exceptions) and which it is scarcely feasible to describe further without illustrations.

V. Reagents and Apparatus.

Concent'd hydrochloric or muriatic acid C. P.
" nitric " "
" sulphuric " "
" acetic " "
Glacial acetic acid.
Solution of caustic potash or caustic soda, 1 pint to 2 of water.
Solution of sodium carbonate, 1 pint water 3 pints sodium carbonate.
Liquor ammoniæ.
Solution of sulphate of copper (1 to 10 or 20).
Solution of silver nitrate 1 to 8 of water.
Subnitrate of bismuth.
Chloroform.
Alcohol.
Common salt.

Apparatus.—Test-tubes, conical glasses, litmus paper, urinometer and glass, spirit lamp or Bunsen burner, microscope and lenses, filter paper, glass vessels, rods, etc., etc.

VI. Order of Analysis.

The urine is collected in a large vessel and after standing for a few hours the upper part is poured off and the sedi-

ment put aside for microscopical examination. After noting the amount in twenty-four hours, color, consistency, transparency, smell, reaction, specific gravity and quantity of sediment, a little of the clear urine is poured into a test tube and heated to the boiling point. If a cloudiness rises it is due either to albumen or to the earthy phosphates. Add one or two drops of acetic acid and if the cloudiness disappear it was due to the phosphates; if it remain it is albumen. Then add one-half as much of a caustic potash solution as there is urine in the test tube and if albumen be present it will be dissolved while the earthy phosphates fall as a thick white cloud to the bottom of the tube. If the earthy phosphates become brown on heating, sugar is most probably present, if red, blood coloring matter. In the latter case albumen is probably also present and the presence of the hæmin crystals and the red blood corpuscles may be demonstrated by the microscope. The sediment should be then examined microscopically. In making many examinations it is generally more convenient to have a blank form in which the results may be systematically recorded for oneself or for another physician.

The following will be found convenient:

Examination of Urine.

For.....at the request of
Dr.....

Physical Properties.

Quantity in 24 hrs.... Odor.....
Color..... Specific gravity.....
Reaction.....
Quantity and character of the sediment.....

Abnormal Constituents in Solution.

Albumen..... Bile.....
Sugar.....

Sediment.

Casts..... Oil.....
Pus..... Crystals.....
Blood..... Date.....